

Having thus defined the invention, the following is claimed:

1. An electric arc welder for performing a given weld process with selected current waveform performed between an electrode and a workpiece, said welder comprising a controller with a digital processor, a sensor for reading the instantaneous weld current, and a circuit to convert said instantaneous current into a digital representation of the level of said instantaneous weld current, said digital processor having a program circuit to periodically read and square said digital representation at a given rate, a register for summing a number N of said square digital representation to give a summed value, and an algorithm for periodically dividing the summed value by said number N to provide a quotient and then taking the square root of said quotient to thereby digitally construct a rms signal representing the root mean square of said weld current.

2. An electric arc welder as defined in claim 1 wherein said controller includes a feedback control loop with an error detector for generating a current control signal based upon the relationship of two signals, the first signal of which includes said rms signal.

3. An electric arc welder as defined in claim 2 including a circuit to create an average current signal representing the average weld current and a summing circuit to create said first signal by adding values proportional to said rms signal and said average signal.

4. An electric arc welder as defined in claim 3 wherein said first signal includes a first contributing component equal to a times average current signal and b times said rms signal.

5. An electric arc welder as defined in claim 4 wherein  $a+b=1$ .
6. An electric arc welder as defined in claim 5 wherein  $b$  is greater than  $a$ .
7. An electric arc welder as defined in claim 4 wherein  $b$  is greater than  $a$ .
8. An electric arc welder as defined in claim 3 wherein said first signal includes a first contributing component equal to  $a$  times average current signal and  $b$  times said rms signal.
9. An electric arc welder as defined in claim 8 wherein  $a+b=1$ .
10. An electric arc welder as defined in claim 9 wherein  $b$  is greater than  $a$ .
11. An electric arc welder as defined in claim 8 wherein  $b$  is greater than  $a$ .
12. An electric arc welder as defined in claim 11 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

13. An electric arc welder as defined in claim 10 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

14. An electric arc welder as defined in claim 9 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

15. An electric arc welder as defined in claim 8 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

16. An electric arc welder as defined in claim 7 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

17. An electric arc welder as defined in claim 6 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

18. An electric arc welder as defined in claim 5 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

19. An electric arc welder as defined in claim 4 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

20. An electric arc welder as defined in claim 3 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

21. An electric arc welder as defined in claim 2 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

22. An electric arc welder as defined in claim 1 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

23. An electric arc welder as defined in claim 1 wherein said given rate is less than about 40 kHz.

24. An electric arc welder as defined in claim 1 wherein said given rate is in the general range of 100 kHz to 5 kHz.

25. An electric arc welder as defined in claim 24 wherein said digital processor has a first and second register for summing said squared digital representations, a circuit controlled by said waveform to create an event signal at a given location in said waveform, and a program to alternate said first and second register upon creation of said event signal.

26. An electric arc welder as defined in claim 22 wherein said digital processor has a first and second register for summing said squared digital representations, a circuit controlled by said waveform to create an event signal at a given location in said waveform, and a program to alternate said first and second register upon creation of said event signal.

27. An electric arc welder as defined in claim 2 wherein said digital processor has a first and second register for summing said squared digital representations, a circuit controlled by said waveform to create an event signal at a given location in said waveform, and a program to alternate said first and second register upon creation of said event signal.

28. An electric arc welder as defined in claim 1 wherein said digital processor has a first and second register for summing said squared digital representations, a circuit controlled by said waveform to create an event signal at a given location in said waveform, and a program to alternate said first and second register upon creation of said event signal.

29. An electric arc welder as defined in claim 28 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

30. An electric arc welder as defined in claim 27 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

31. An electric arc welder as defined in claim 26 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

32. An electric arc welder as defined in claim 25 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

33. An electric arc welder as defined in claim 24 wherein said digital processor includes a circuit controlled by said waveform to create an event signal at a given location in said waveform and a program to initiate said algorithm upon creation of said event signal.

34. An electric arc welder as defined in claim 23 wherein said digital processor includes a circuit controlled by said waveform to create an event signal at a given location in said waveform and a program to initiate said algorithm upon creation of said event signal.

35. An electric arc welder as defined in claim 22 wherein said digital processor includes a circuit controlled by said waveform to create an event signal at a given location in said waveform and a program to initiate said algorithm upon creation of said event signal.

36. An electric arc welder as defined in claim 21 wherein said digital processor includes a circuit controlled by said waveform to create an event signal at a given location in said waveform and a program to initiate said algorithm upon creation of said event signal.

37. An electric arc welder as defined in claim 20 wherein said digital processor includes a circuit controlled by said waveform to create an event signal at a given location in said waveform and a program to initiate said algorithm upon creation of said event signal.

38. An electric arc welder as defined in claim 4 wherein said digital processor includes a circuit controlled by said waveform to create an event signal at a given location in said waveform and a program to initiate said algorithm upon creation of said event signal.

39. An electric arc welder as defined in claim 3 wherein said digital processor includes a circuit controlled by said waveform to create an event signal at a given location in said waveform and a program to initiate said algorithm upon creation of said event signal.

40. An electric arc welder as defined in claim 2 wherein said digital processor includes a circuit controlled by said waveform to create an event signal at a given location in said waveform and a program to initiate said algorithm upon creation of said event signal.

41. An electric arc welder as defined in claim 1 wherein said digital processor includes a circuit controlled by said waveform to create an event signal at a given location in said waveform and a program to initiate said algorithm upon creation of said event signal.

42. An electric arc welder as defined in claim 41 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.



43. An electric arc welder as defined in claim 40 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

44. An electric arc welder as defined in claim 39 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

45. An electric arc welder as defined in claim 38 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

46. An electric arc welder as defined in claim 42 including a digital counter to count at said given rate to obtain the number N upon creation of said event signal.

47. An electric arc welder as defined in claim 41 including a digital counter to count at said given rate to obtain the number N upon creation of said event signal.

48. An electric arc welder as defined in claim 40 including a digital counter to count at said given rate to obtain the number N upon creation of said event signal.

49. An electric arc welder as defined in claim 39 including a digital counter to count at said given rate to obtain the number N upon creation of said event signal.

50. An electric arc welder as defined in claim 33 including a digital counter to count at said given rate to obtain the number N upon creation of said event signal.

51. An electric arc welder as defined in claim 32 including a digital counter to count at said given rate to obtain the number N upon creation of said event signal.

52. An electric arc welder as defined in claim 28 including a digital counter to count at said given rate to obtain the number N upon creation of said event signal.

53. An electric arc welder as defined in claim 27 including a digital counter to count at said given rate to obtain the number N upon creation of said event signal.

54. An electric arc welder as defined in claim 25 including a digital counter to count at said given rate to obtain the number N upon creation of said event signal.

55. An electric arc welder for performing a given weld process with selected current waveform performed between an electrode and a workpiece, said welder comprising a controller with a digital processor, a sensor for reading the instantaneous weld voltage, and a circuit to convert

said instantaneous voltage into a digital representation of the level of said instantaneous weld  
 voltage, said digital processor having a program circuit to periodically read and square said digital  
 representation at a given rate, a register for summing a number N of said square digital representation  
 to give a summed value of the voltage squared, and an algorithm for periodically dividing and  
 summed value by said number N to provide a quotient and then taking the square root of said  
 quotient to thereby digitally construct a rms signal representing the root mean square of said weld  
 voltage.

56. An electric arc welder as defined in claim 55 wherein said controller includes a  
 feedback control loop with an error detector for generating a voltage control signal based upon the  
 relationship of two signals, the first signal of which includes said rms signal.

57. An electric arc welder as defined in claim 56 including a circuit to create an average  
 voltage signal representing the average weld voltage and a summing circuit to create said first signal  
 by adding values proportional to said rms signal and said average signal.

58. An electric arc welder as defined in claim 57 wherein said first signal includes a first  
 contributing component equal to a times average voltage signal and b times said rms signal.

59. An electric arc welder as defined in claim 58 wherein  $a+b=1$ .

60. An electric arc welder as defined in claim 59 wherein b is greater than a.

61. An electric arc welder as defined in claim 55 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

62. An electric arc welder as defined in claim 55 wherein said given rate is less than about 40 kHz.

63. An electric arc welder as defined in claim 55 wherein said given rate is in the general range of 100 kHz to 5 kHz.

64. An electric arc welder for performing a given welding process with a selected current waveform performed between an electrode and a workpiece, said welder comprising a controller with a digital processor, a sensor for reading the instantaneous weld current of said waveform and a circuit to convert said instantaneous weld current into a digital representation of the level of said instantaneous weld current, said digital processor having a program circuit to periodically read said digital representation at a given rate and an algorithm for processing said digital representations into a current signal.

65. A welder as defined in claim 64 wherein said current signal is a rms signal.

66. An electric arc welder as defined in claim 65 wherein said controller includes a feedback control loop with an error detector for generating a current control signal based upon the relationship of two signals, the first signal of which includes said rms signal.

67. An electric arc welder as defined in claim 66 including a circuit to create an average current signal representing the average weld current and a summing circuit to create said first signal by adding values proportional to said rms signal and said average signal.

68. An electric arc welder as defined in claim 67 wherein said first signal includes a first contributing component equal to  $a$  times average current signal and  $b$  times said rms signal.

69. An electric arc welder as defined in claim 68 wherein  $a+b=1$ .

70. An electric arc welder as defined in claim 67 wherein  $a+b=1$ .

71. An electric arc welder as defined in claim 70 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

72. An electric arc welder as defined in claim 67 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

73. An electric arc welder as defined in claim 68 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

74. An electric arc welder as defined in claim 67 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

75. An electric arc welder as defined in claim 66 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

76. An electric arc welder as defined in claim 65 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

77. An electric arc welder as defined in claim 64 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

78. An electric arc welder as defined in claim 64 wherein said given rate is less than about 40 kHz.

79. An electric arc welder as defined in claim 64 wherein said given rate is in the general range of 100 kHz to 5 kHz.

80. An electric arc welder as defined in claim 64 wherein said digital processor includes a circuit controlled by said waveform to create an event signal at a given location in said waveform and a program to initiate said algorithm upon creation of said event signal.

81. An electric arc welder as defined in claim 65 wherein said given rate is less than about 40 kHz.

82. An electric arc welder as defined in claim 65 wherein said given rate is in the general range of 100 kHz to 5 kHz.

83. An electric arc welder as defined in claim 65 wherein said digital processor includes a circuit controlled by said waveform to create an event signal at a given location in said waveform and a program to initiate said algorithm upon creation of said event signal.

84. An electric arc welder for performing a given weld process with a selected current waveform performed between an electrode and a workpiece, said welder comprising a controller with a digital processor, said controller having a waveform generator for creating a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude for each pulse creating said waveform and a feedback current control loop with an error detector for generating a current control signal based upon the relationship of two signals, the first signal of which includes an actual rms current signal generated by an algorithm processed by said digital processor.

85. A welder as defined in claim 84 wherein said second of said two signals is a signal representing the desired current rms signal.

86. An electric arc welder as defined in claim 85 wherein said first signal includes a first contributing component equal to a times average current signal and b times said rms signal.

87. An electric arc welder as defined in claim 84 wherein said first signal includes a first contributing component equal to a times average current signal and b times said rms signal.



88. An electric arc welder as defined in claim 87 wherein  $a+b=1$ .
89. An electric arc welder as defined in claim 88 wherein  $b$  is greater than  $a$ .
90. An electric arc welder as defined in claim 87 wherein  $b$  is greater than  $a$ .
91. An electric arc welder as defined in claim 85 wherein said given rate is less than about 40 kHz.
92. An electric arc welder as defined in claim 84 wherein said given rate is less than about 40 kHz.
93. An electric arc welder as defined in claim 85 wherein said given rate is in the general range of 100 kHz to 5 kHz.
94. An electric arc welder as defined in claim 84 wherein said given rate is in the general range of 100 kHz to 5 kHz.
95. A method of operating an electric arc welder for performing a given weld process with selected current waveform performed between an electrode and a workpiece, said welder comprising a controller with a digital processor, said method comprising:

- (a) reading the instantaneous weld current;
- 5 (b) converting said instantaneous current into a digital representation of the level of said instantaneous weld current;
- (c) periodically reading and squaring said digital representation at a given rate;
- (d) summing a number N of said square digital representation to give a summed value;
- (e) periodically dividing and summed value by said number N to provide a quotient; and,
- 10 (f) then taking the square root of said quotient to thereby digitally construct a signal rms representing the root mean square of said weld current.

96. A method as defined in claim 95 wherein said controller includes a feedback control loop with an error detector and the method includes generating a current control signal by said error detector based upon the relationship of two signals, the first signal of which includes said rms signal.

97. A method as defined in claim 95 including:

- (g) creating an average current signal representing the average weld current; and,
- (h) creating said first signal by adding values proportional to said rms signal and said average signal.

98. A method as defined in claim 95 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

99. A method as defined in claim 95 wherein said given rate is less than about 40 kHz.

100. A method as defined in claim 95 wherein said given rate is in the general range of 100 kHz to 5 kHz.

101. An electric arc welder for performing a given weld process with a selected current waveform between an electrode and workpiece, said welder comprising: a circuit to sample the weld current of said waveform at a given rate, a detector to create an event signal at a given location in said waveform, a counter to count the number of samples between successive event signals, a digital processor with an algorithm to calculate a rms value for the weld current based upon said samples and said number.

102. An electric arc welder as defined in claim 101 wherein said current waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with the magnitude of each pulse controlled by a wave shaper.

103. An electric arc welder as defined in claim 102 wherein said given rate is less than about 40 kHz.

104. An electric arc welder as defined in claim 102 wherein said given rate is in the general range of 100 kHz to 5 kHz.

105. An electric arc welder as defined in claim 101 wherein said given rate is less than about 40 kHz.

106. An electric arc welder as defined in claim 101 wherein said given rate is in the general range of 100 kHz to 5 kHz.

107. A method of operating an electric arc welder for performing a given weld process with a selected current waveform between an electrode and a workpiece, said method comprising:

- (a) sampling the weld current of said waveform at a given rate;
- (b) creating an event signal at a given location in said waveform;
- (c) counting the number of samples between successive event signals; and,
- (d) calculating a rms value for the weld current based upon said samples and said number.

108. A method as defined in claim 107 comprising:

- (e) creating said current waveform by a number of current pulses occurring at a frequency of at least 18 kHz; and,
- (f) controlling the magnitude of each pulse by a wave shaper.

109. A method as defined in claim 108 wherein said given rate is less than about 40 kHz.

110. A method as defined in claim 107 wherein said given rate is less than about 40 kHz.

111. A method as defined in claim 107 wherein said given rate is in the range of 100 kHz to 5 kHz.

112. A method as defined in claim 108 wherein said given rate is in the range of 100 kHz to 5 kHz.

113. An electric arc welder for performing a given weld process with a selected waveform performed between an electrode and a workpiece, said welder comprising a power source with a controller having a digital processor including a program to calculate the real time power factor of the weld current and weld voltage, said program including an algorithm to calculate the rms weld voltage, the rms weld current and the average power of said power source, a circuit to multiply said  
5 rms current by said rms voltage to produce an rms power level; and a circuit to divide said average power by said rms power to create a value representing the actual real time power factor of said power source.

114. An electric arc welder as defined in claim 113 wherein said controller includes a wave shaper having an input with a value determining the shape of said waveform and an error circuit for comparing said actual real time power factor with a desired power factor to create a corrective value and a circuit to direct said value to said input of said wave shaper whereby said actual real time  
5 power factor is held at said desired power factor.

115. An electric arc welder as defined in claim 114 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

116. An electric arc welder as defined in claim 113 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

117. An electric arc welder for performing a pulse welding process with a selected waveform performed between an electrode and workpiece, said welder comprising a power source with a waveform generator having a control signal input with a value determining the shape of said waveform and a controller with an error amplifier program with a first input representative of the  
5 actual power factor of said power source, a second input representing a desired power factor and an output signal directed to said control input of said wave shape generator wherein said actual power factor is held at said desired power factor by adjusting said waveform.

118. An electric arc welder as defined in claim 117 including a device to manually adjust said desired power factor for adjusting the heat of said weld process.

119. An electric arc welder as defined in claim 118 including a control circuit for holding the rms current of said power source at a desired set value.

120. An electric arc welder as defined in claim 116 including a device to manually adjust the desired power factor for adjusting the heat of said weld process.

121. An electric arc welder as defined in claim 120 including a control circuit for holding the rms current of said power source at a desired set value.

122. An electric arc welder as defined in claim 115 including a device to manually adjust said desired power factor for adjusting the heat of said weld process.

123. An electric arc welder as defined in claim 122 including a control circuit for holding the rms current of said power source at a desired set value.

124. An electric arc welder as defined in claim 114 including a device to manually adjust said desired power factor for adjusting the heat of said weld process.

125. An electric arc welder as defined in claim 124 including a control circuit for holding the rms current of said power source at a desired set value.

126. An electric arc welder as defined in claim 113 including a device to manually adjust the desired power factor for adjusting the heat of said weld process.

127. An electric arc welder as defined in claim 126 including a control circuit for holding the rms current of said power source at a desired set value.

128. An electric arc welder as defined in claim 117 including a control circuit for holding the rms current of said power source at a desired set value.

129. An electric arc welder as defined in claim 116 including a control circuit for holding the rms current of said power source at a desired set value.

130. An electric arc welder as defined in claim 115 including a control circuit for holding the rms current of said power source at a desired set value.

131. An electric arc welder as defined in claim 114 including a control circuit for holding the rms current of said power source at a desired set value.

132. An electric arc welder as defined in claim 113 including a control circuit for holding the rms current of said power source at a desired set value.

133. A method of controlling an electric arc welder for performing a given weld process with a selected waveform performed by a power source between an electrode and workpiece, said method comprising:



(a) calculating the actual power factor of said power source using the rms current and rms  
5 voltage;

(b) selecting a desired power factor for said power source;

(c) obtaining an error signal by comparing said actual power factor of power source to  
said desired power factor of the power source; and,

(d) adjusting said waveform by said error signal whereby said actual power factor is  
10 maintained at said desired power factor.

134. The method as defined in claim 133 including manually adjusting said desired power  
factor to control the heat of said weld process.

135. A method as defined in claim 133 including holding said rms current constant as said  
desired power factor is adjusted.

136. A method as defined in claim 135 wherein said waveform is created by a number of  
current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled  
by a wave shaper.

137. A method as defined in claim 134 wherein said waveform is created by a number of  
current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled  
by a wave shaper.

138. A method as defined in claim 133 wherein said waveform is created by a number of current pulses occurring at a frequency of at least 18 kHz with a magnitude of each pulse controlled by a wave shaper.

139. An electric arc welder for performing a given weld process with a selected waveform performed between an electrode and a workpiece, said welder comprising a power source, a circuit for calculating the rms current of said power source, a circuit for determining the average current of said power source and a controller with a closed loop current feedback circuit responsive to a combination of said rms current and said average current.

140. An electric arc welder as defined in claim 139 wherein said combination includes a substantially higher rms current component.